Plastics Analysis Lab
Lesson Plans

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Exploration

What do the students already know? What will happen if...? This part of the learning cycle actively involves the student with his or her peers with minimal teacher input.

Previous Week:
Students bring to class plastic containers with resin identification codes embossed on them (1-6). An example of the code:

You will notice that in the cases of codes #1 and #3 we refer to the resins as PET and PVC, respectively. However, the actual codes on the containers are PETE and V. These resins are correctly referred to in both ways.

It might be a good idea to award bonus points for samples brought to school so that each class has a wide variety of containers to study. The containers are collected in a large box in the classroom. Before the first class period on the study of plastics, the teacher must remove the embossed code on the bottom of the containers. Just cut down the side of the container and remove it. It is okay to partially destroy the container! It is not necessary to save the codes nor to identify which container was coded with a particular number.

Student groups may be given pieces of containers for this activity. They do not need the whole container. It works well to have plastic bags of containers ready for each group in the class.

Day One:
Introduce the topic of plastics by asking your students what comes into their minds when the word "plastic" is heard. At some point in the discussion, the resin identification codes will be mentioned. Ask your students what they think the numbers mean. Finally, place an overhead transparency of "Plastic Resin Identification Codes" on the overhead projector (using the handout included in *Classroom Materials* below to make a transparency) and tell them the names for the letter abbreviations. At this point it is not expected that students will know what is meant by the long chemical names but the introduction is important.

Place students into cooperative groups. Give each group a felt tip marker, a bag of plastic containers with the plastic code removed, and the sheet Classification of Plastic Containers (see *Classroom Materials* below). Challenge the groups of students to put the containers in their appropriate groupings (1-6). These are: (1) PET, (2) HDPE, (3) PVC, (4) LDPE, (5) PP, (6) PS. Sharing their ideas with others in their group and recording their thoughts is appropriate. A student recorder should be assigned to each group. Toward the end of the class period, one representative will share with the class their classifications of the containers and how the group arrived at their decisions. A lively discussion may occur because the students don't have much information about the categories. Keep each group's categories of plastics in a separate place or in a bag marked for that group. These will be used later. A marker should be used to identify each container with the plastic number that they assigned.

Classroom worksheets (see Appendix):

- Table of Plastic Resin Identification Codes

- Classification of Plastics Containers

Concept Introduction

Day Two:
The teacher plays an active role in the introduction of new ideas. This is a laboratory exercise where students work in pairs or small groups. The Plastics Analysis Lab may take two days for larger classes. Use the enclosed student laboratory instructions and worksheets for this activity.

Plastics Analysis Lab
(modified from Christopher S. Kollman, Chem 13 News, January 1994)

1. Before conducting this lab, students should be familiar with the concept of density.

2. If students are not familiar with flow charts, we suggest that you try having them read the chart and discuss its meaning before the lab. Have students tell which plastic floats in alcohol and oil. Will this same plastic float in water? Which plastic has a green flame with the copper wire test? Will PS soften in acetone?

3. The four test areas must be set up before the class starts. Be sure to keep the flammable liquids and the hot plate in separate locations for safety reasons. Also, make sure students wear safety glasses and avoid breathing in fumes during the experiment.

4. If you do not want your students to have open flames in the room to do the copper wire test, have your students bring the resin to you to demonstrate this test for them. Using insulated copper wire by peeling off the end of the insulation also works well for this test.

5. Each group of students needs samples of the six recycled resins to identify. Each group should have about 10 pellets of each type.

6. Acetone is the active ingredient in some fingernail polish removers so your drugstore is a good source for this chemical. Please read the label of the fingernail polish remover to make sure that the primary active ingredient is acetone. If you use fingernail polish remover instead of acetone, students must leave the plastic sample in the liquid for a longer period of time in order to detect any softening of the plastic. Please check the timing of this test before the students do the lab. A special container must be provided for the used resins since acetone on the pellet may be a fire hazard until the acetone evaporates.

7. Isopropyl rubbing alcohol is also available from the drugstore, but make sure it is 70 percent to 90 percent, since the density is not one gram/mL. When preparing the materials listed on page 27, 60 grams of isopropyl rubbing alcohol is equal to 65 mL for the alcohol solution.

8. Mazola® corn oil has the correct density to separate #4 and #5 resins so do not substitute another kind of oil.

9. Have your students place their used resins in appropriate containers at the end of the laboratory period so that you can recycle them for another class. Have labeled containers set up for the each resin.

10. The PET resin in this kit does not soften in boiling water for the heat test. Students will not have to use this test to distinguish between PS and PET because the acetone test will identify both. Most bottles made out of PET will soften in boiling water, so students can use this property when testing containers. To demonstrate this in class, simply use pre-cut strips of soda bottles.

Answers to "Conclusion" questions

1. Identify the resins by color.
1. PET — Polyethylene Terephthalate (white)
2. HDPE — High density Polyethylene (off-white)
3. PVC — Polyvinyl Chloride (gray)
4. LDPE — Low density Polyethylene (brown)
5. PP — Polypropylene (black)
6. PS — Polystyrene (blue)

2. HDPE, LDPE and PP because their densities are less than 1.00 g/mL.

3. Do not use PET because it softens at 100 degrees Celsius.

4. The bottle was made of PS since it softens in acetone or fingernail polish remover.

5. The alcohol solution was about 0.94 g/mL since HDPE sinks in this solution.

6. Adhering air bubbles will add buoyancy to the sample and therefore the density will be less than expected.

7. The mixture of LDPE and PP will not show up in the water density test since their densities are so similar. A mixture of PET and HDPE will change the density depending on how much of each is present in the mixture.

Classroom worksheets (see Appendix):

- Plastics Analysis Lab

- Observations and Notes on Reactions

- Conclusions

Concept Application

Can students take the containers that they originally classified in Day One and check their accuracy?

Day Three:

Student assessment will be done in the laboratory setting. The original groups of students from Day One will perform tests on their containers to see if they were correct in their groupings of the plastics. (Use this section's student data sheet, "Assessment of Plastic Container Classification.") Allow students to make changes to their groupings after their laboratory experience with the resins but before they actually test the containers. Assessment is based on students being able to follow the flow chart using their plastic containers, not the resins. Each container must be tested by cutting a 1 cm X 1 cm piece or by using a hole punch to obtain the circle for test purposes. Grading is NOT based on the correctness of the original groupings! At this point it is possible to observe the groups at work for a general grade or to give a written assignment for the group to explain their results.

Another way to assess students' thinking about plastics is to have them draw a cartoon-type sketch telling the different steps needed in a factory to separate plastics for recycling. Challenge students to make this efficient, cost-effective, a good use of man/woman power, etc. Students could also be encouraged to make a videotape of their "factory." Local groups that recycle plastics could be invited to speak to the class or a field trip might be possible. See Section 4 of this kit for the phone number of your state recycling office to contact for help with this.

The videotape, "Not Your Average Field Trip," from the Society of Plastics Engineers, is 19 minutes long and appropriate for the middle level student. It includes discussions of plastics and the engineering needed for football helmets, artificial limbs, auto design, and recycling.

Classroom worksheets (see Appendix):

- Assessment of Plastic Container Classification

Appendix A

Plastic Resin Identification Codes

1 = PETE = Polyethylene Terephthalate (PET)

2 = HDPE = High Density Polyethylene

3 = V = Polyvinyl Chloride (PVC or Vinyl)

4 = LDPE = Low Density Polyethylene

5 = PP = Polypropylene

6 = PS = Polystyrene

Appendix B

Classification of Plastic Containers

Group Members:

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Group Recorder:

Place each container in a specific resin code category. There are SIX categories. Use physical properties to classify the containers. Using your senses, examine each container for texture, gloss or shine, color, flexibility, transparency, odor, etc. Remember that all six categories may not be represented by the containers you brought to school for this exercise. Use a marker to place the number of the code on each container once the group has made its final decisions.

Resin Code	***Container Descriptions***	***Physical Properties***
1- PET		
2- HDPE		
3- PVC		
4- LDPE		
5- PP		
6- PS		

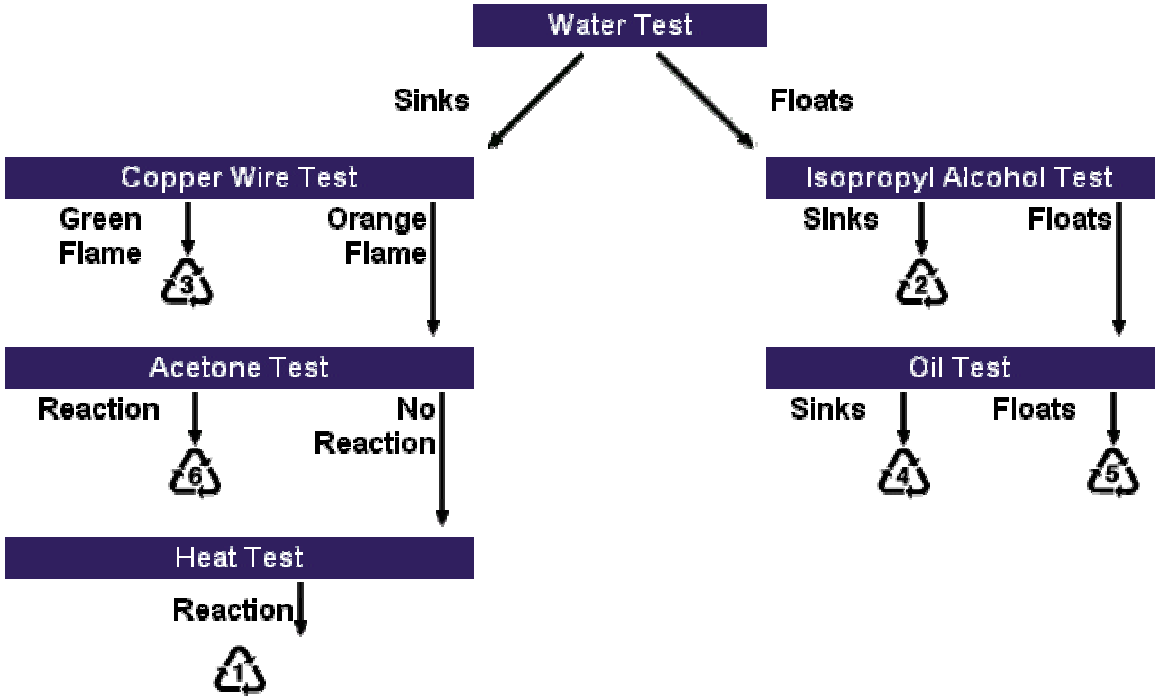
Pick a spokesperson to describe your choices for the class discussion.

Appendix C

Plastics Analysis Lab

Student Name:

Activity Flow Chart



Density Table	
Substance	**Density**
Water	1.00
(1) PET	1.38-1.39
(2) HDPE	0.95-0.97
(3) PVC	1.16-1.35
(4) LDPE	0.92-0.94
(5) PP	0.90-0.91
(6) PS	1.05-1.07

Purpose:

To identify the six kinds of recycled plastic resins by measuring their physical and chemical properties.

Background:

The plastics industry uses resin pellets to make plastic containers. Each of the recycled resins is color-coded to help you keep them separate in this analysis, but each may be made in any color. These resin samples have come from recycled products.

Materials:

6 samples of resin pellets
250 mL beakers
100 mL beaker
Bunsen burners or alcohol burners
forceps, tongs, and plastic spoons
1 hot plate
stirring rods or Popsicle sticks
copper wires (5 cm, 20 gauge)
50 mL acetone
60 g isopropyl alcohol (70%)
goggles
glass petri dish
100 mL corn oil
small cups to hold resin samples

Procedure:

1. Notice the test areas in the room. Some tests are to be done only at those locations, while others will be performed at your lab desk. There are four specific test areas in the room that your teacher has set up:

a. Acetone Test—Have 50 mL of acetone in a 100 mL beaker covered with a glass petri dish. KEEP THIS TEST AREA AWAY FROM FLAMES. *Acetone is highly flammable and must be kept away from flames and covered when not in use.* Have tongs or forceps available.

b. Heat Test—Have 125 mL water in a 250 mL beaker on a hot plate. Keep this at a rolling boil. Have tongs available. Make sure this does not boil dry!

c. Isopropyl Alcohol Test—Put 60 g (or 65 mL) isopropyl rubbing alcohol (70%) in a 250 mL beaker and add enough water to make 100 g (or 100 mL) of solution. Mix. Have tongs or forceps available. Have plastic spoons available.

d. Oil Test—Put 100 mL of corn oil in a 250 mL beaker. Have tongs or forceps available. Have plastic spoons available.

The other two tests, water and copper wire, are to be done at your lab station.

2. You and your lab partner are given six different kinds of recycled resins. You should have about 10 pellets of each resin or color. Use the flow chart below and the descriptions of the tests to identify the resins. Keep notes of your observations on the sheet provided.

The following resins are the six you need to identify:

1. PET—polyethylene terephthalate
2. HDPE—high density polyethylene
3. PVC—polyvinyl chloride
4. LDPE—low density polyethylene
5. PP—polypropylene
6. PS—polystyrene

Water Test

At your lab desk, place one pellet of each of the recycled resin samples in 100 mL of tap water at room temperature in a 250 mL beaker. Poke the pieces with a glass stirring rod to knock off any adhering bubbles and try to make them sink. Note whether the sample floats or sinks. Do not pour the resin samples down the sink — they are insoluble in water! Take the resin pellets out of the water with your fingers and save the pellets for later. Use the Density Table on the previous page to find the density ranges for each type of plastic. Proceed down the flow chart, do the tests indicated, and record all your observations on the sheet provided.

Copper Wire Test

At your lab desk, using forceps, hold the 5 cm length of copper wire in the hot part of the flame of a Bunsen burner or alcohol burner until it is red hot. Remove from the flame and carefully touch a resin pellet with the hot wire. It may stick to the wire at this point so you will need to take another pair of forceps to pull the pellet off the wire. Place the wire with some plastic glob on it (not the pellet) back in the flame, observing the color of the flame that comes from the glob. You will notice a green or orange flame color. Quench the sample in a beaker of water to stop the burning and cool the wire. Proceed down the flow chart.

Acetone Test

Take your sample resin to the acetone test area in the room. Using tongs, place a pellet in acetone for 20 seconds. Remove the pellet and press firmly between your fingers. The polymer chains may "loosen up" and feel soft and sticky. Try to scrape off some plastic with your fingernail. There may be no reaction to this scrape test. Discard the pellet in a container provided. (Note: If you are using fingernail polish remover instead of acetone, leave the resin pellet in for at least one minute. Use your fingernail to try to scrape the pellet to see if the outer layer has softened.) Place the used resin pellet in the special container for waste. Proceed down the flow chart.

Heat Test

Take your sample resin to the heat test area. Using tongs, hold one pellet in boiling water for 30 seconds. PET (1) has a relatively low softening point and will show some reaction to the 100 degree Celsius water. Press the pellet between your fingers to see if it feels softened after you remove it from the water. Discard the pellet in the trash can. Proceed down the flow chart.

Isopropyl Alcohol Test

Take five resin pellets to the isopropyl alcohol test area. Place the pellets in the solution and poke the pellets with a stirring rod to release any bubbles. Note whether the pellets float or sink. Scoop the pellets out with a plastic spoon and take the pellets back to your lab station. Proceed down the flow chart.

Oil Test

Take five resin pellets to the oil test area. Place them in the oil and poke the pellets with a stirring rod to release any bubbles. Note whether the pellets float or sink. Identify the resin from the flow chart. Scoop the pellets out with a plastic spoon and wipe them off with a paper towel. Take the pellets back to your lab station.

Clean Up

Please recycle your resins in the appropriate containers. Try not to mix the resins.

Appendix D

Observations and Notes on Reactions

Student Name :

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Pellet color:

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Water test results:

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Other test results:

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Pellet color:

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Water test results:

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Other test results:

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Pellet color:

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Water test results:

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Other test results:

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Pellet color:

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Water test results:

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Other test results:

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Pellet color:

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Water test results:

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Other test results:

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Appendix E

Conculsions

Student Name :

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1. Identify the resins by color.

1. PET - polyethylene terephthalate

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2. HDPE - high density polyethylene

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3. PVC - polyvinyl chloride

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4. LDPE - low density polyethylene

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5. PP - polypropylene

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6. PS - polystyrene

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2. Your boat is sinking about two miles off shore and you are not a good swimmer. You notice six large solid plastic blocks labeled 1, 2, 3, 4, 5, 6. Which three should you grab? Why?

3. You wish to make a plastic handle for a cooking pan out of recycled plastic. Which plastic should you avoid?

4. You decide to jazz up your bathroom cabinet by transferring your fingernail polish remover into a more stylish container. The next day, reaching for the bottle, you find a messy blob. What was the plastic used in this stylish bottle? What is the active ingredient in the fingernail polish remover (answer is in the lab instructions)?

5. From what you observed, tell the approximate density of the isopropyl alcohol and water solution and explain.

6. Why is it important to dislodge any adhering bubbles in the density tests?

7. Sometimes plastic containers are made from two polymers and not just one. What would happen to the water density test if LDPE and PP were mixed? If PET and HDPE were mixed?

Appendix F

Assessment of Plastic Container Classification

Group Members:

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Purpose:
To use your skills of observation, laboratory testing, and reasoning to classify plastic containers into their correct resin identification codes.

Procedure:

1. Take your original plastic container classification sheet that the group did earlier and decide if the group is still satisfied with the placement of the containers in the categories. If you want to change any or all, you may do so now. Just cross out the number on the container and assign a new number for a different resin code.

2. Take scissors or a hole punch and cut a 1 cm X 1 cm piece or circle from one of the containers. Follow the flow chart from the Plastics Analysis Lab to help you identify the correct code for this container. Record your observations. Repeat this step for all of your containers. The group members need to decide who is testing which container. It might be wise to have two people testing the same container for verification of the results.

Container Description	Hypothesized Resin Code	Resin Code from Testing	Physical Characteristics

Use notebook paper if you need more data recording space.

Conclusions:

1. Were the containers as easy to identify as the resin pellets using the flow chart? Explain.

2. How many containers were classified correctly before you did the testing?

3. Why was the percentage of correct classification so low or so high?

4. Which kinds of plastics are now easy for you to identify by just using your senses?

5. Do you think that each plastic container has to be separated from another before a factory can use the recycled plastic to make a new product like plastic wood? Explain.